



PATENT APPLICATION

IN THE U.S. PATENT AND TRADEMARK OFFICE

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Applicants: Yoshio MATSUZAKI et al

For: METHOD OF MANUFACTURING SOLID OXIDE FUEL CELL MODULE

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Commissioner for Patents
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APPELLANTS' BRIEF ON APPEAL

Sir:

This is an appeal from the decision of the Examiner dated December 23, 2009, finally rejecting Claims 7-47.

REAL PARTY IN INTEREST

Tokyo Gas Company, Ltd. is the assignee of the present application and the real party in interest.

RELATED APPEALS AND INTERFERENCES

There are no related appeals and interferences with the present application.

STATUS OF CLAIMS

Claims 1-6 and 42-47 have been canceled. Claims 7-41 are pending and are the claims under consideration on appeal.

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STATUS OF AMENDMENTS

The Amendment After Final Rejection dated April 23, 2010 has been entered by the Examiner. A Second Amendment After Rejection accompanies this Appeal Brief in order to correct an obvious typographical error contained in Claim 41.

SUMMARY OF CLAIMED SUBJECT MATTER

Appellants' invention, as defined in independent Claim 36, is directed to a method of manufacturing a solid oxide fuel cell module comprising a plurality of cells (numeral 2 in Figure 1(a)), provided adjacent to one another and electrically connected in series by an interconnector (numeral 6 in Figure 1(c)) provided therebetween, each cell comprising a fuel electrode (numeral 3 in Figure 1(c)), an electrolyte (numeral 4 in Figure 1(c)) and an air electrode (numeral 5 in Figure 1(c)) sequentially formed on a surface of a substrate (numeral 1 in Figure 1(c)) having an internal flow path (numeral 7 in Figure 1(c)) provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating. The method comprises the steps of providing respective fuel electrodes and respective electrolytes on the surface of the substrate, co-sintering the respective fuel electrodes and respective electrolytes (clean copy of specification page 5, lines 7-17), providing a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that would have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes (clean copy of specification page 5, lines 19-22 and page 32, lines 21-25), forming respective air electrodes on the respective electrolytes (clean copy of specification page 5, lines 23 and 24) and electrically connecting the respective electrodes with the respective first parts of the respective interconnectors via respective second parts of the

interconnectors which have a density less than the respective first parts (clean copy of specification page 33, lines 5-17).

Appellants' invention, as defined by independent Claim 37, is directed to a method of manufacturing a solid oxide fuel cell module made up of a plurality of cells (numeral 2 in Figure 1(a)) provided adjacent to one another and electrically connected in series by an interconnector (numeral 6 in Figure 1(c)) provided therebetween. Each cell comprising a fuel electrode (numeral 3 in Figure 1(c)), an electrolyte (numeral 4 in Figure 1(c)) and an air electrode (numeral 5 in Figure 1(c)) sequentially formed on a surface of a substrate (numeral 1 in Figure 1(c)) having an internal fuel flow path (numeral 7 in Figure 1(c)) provided therein, at least the surface of the substrate in contact with the cells and interconnectors being insulating. The method comprises the steps of providing respective fuel electrodes and respective electrolytes on the surface of the substrate, co-sintering the substrate, the respective fuel electrodes and the respective electrolytes (clean copy of specification page 6, lines 1-3), providing a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that would have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and respective electrolytes (clean copy of specification page 6, lines 3-8 and page 32, lines 21-25), forming respective air electrodes on the respective electrolytes and electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts (specification page 6, lines 7-10 and specification page 32, lines 10-16).

Appellants invention as defined in independent Claim 38 is directed to a method of manufacturing a solid oxide fuel cell module made up of a plurality of cells (numeral 2 in

Figure 1(a)) provided adjacent to one another and electrically connected in series by an interconnector (numeral 6 in Figure 1(c)) provided therebetween, each cell comprising a fuel electrode (numeral 3 in Figure 1(c)), an electrolyte (numeral 4 in Figure 1(c)) and an air electrode (numeral 5 in Figure 1(c)) sequentially formed on a surface of a substrate (numeral 1 in Figure 1(c)) having an internal fuel flow path (numeral 7 in Figure 1(c)) provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating. The method comprises the steps of providing respective fuel electrodes, respective electrolytes and respective interconnectors on the surface of the substrate, a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that would have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes (clean copy of specification page 6, lines 11-20 and specification page 32, lines 21-25), co-sintering the respective fuel electrodes, respective electrolytes and respective interconnectors, forming respective air electrodes on the respective electrolytes and electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts (clean copy of specification page 6, lines 20-29 and specification page 32, lines 28-34).

Appellants' invention, as defined by independent Claim 39, is directed to a method of manufacturing a solid oxide fuel cell module made up of a plurality of cells (numeral 2 in Figure 1(a)) provided adjacent to one another and electrically connected in series by an interconnector (numeral 6 in Figure 1(c)) provided therebetween, each cell comprising a fuel electrode (numeral 3 in Figure 1(c)), an electrolyte (numeral 4 in Figure 1(c)) and an air electrode

(numeral 5 in Figure 1(c)) sequentially formed on a surface of a substrate (numeral 1 in Figure 1(c)) having an internal fuel flow path (numeral 7 in Figure 1(c)) provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating (clean copy of specification page 6, lines 31-36 and page 7, line 1). The method comprises the steps of providing respective fuel electrodes, respective electrolytes and respective interconnectors on the surface of the substrate, a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that would have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes (clean copy of specification page 7, lines 1-3 and specification page 32, lines 21-25), co-sintering of the substrate, the respective fuel electrodes, respective electrolytes and respective interconnectors, forming respective air electrodes on the respective electrolytes and electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts (clean copy of specification page 7, lines 4-12 and specification page 32, lines 8-34).

Appellants' invention as defined in independent Claim 40 is directed to a method of manufacturing a solid oxide fuel cell module made up of a plurality of cells (numeral 2 in Figure 1(a)) provided adjacent to one another and electrically connected in series by an interconnector (numeral 6 in Figure 1(c)) provided therebetween, each cell comprising a fuel electrode (numeral 3 in Figure 1(c)), an electrolyte (numeral 4 in Figure 1(c)) and an air electrode (numeral 5 in Figure 1(c)) sequentially formed on a surface of a substrate (numeral 1 in Figure 1(c)) having an internal fuel flow path (numeral 7 in Figure 1 (c)) provided therein, at least the surface of the

substrate in contact with the cells and interconnectors being electrically insulating. The method comprises the steps of providing respective fuel electrodes on the surface of the substrate, providing a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that would have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes, providing the respective electrolytes on the respective fuel electrodes, co-sintering the respective interconnectors, the respective fuel electrodes and the respective electrolytes (specification page 7, lines 22-32 and specification page 32, lines 21-25), forming respective air electrodes on the respective electrolytes and electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts (clean copy of specification page 7, lines 32-35 and specification page 32, lines 8-34).

Appellants' invention, as defined in independent Claim 41, is directed to a method of manufacturing a solid oxide fuel cell module made up of a plurality of cells (numeral 2 in Figure 1(a)) provided adjacent to one another and electrically connected in series by an interconnector (numeral 6 in Figure 1(c)) provided therebetween. Each cell comprises a fuel electrode (numeral 3 in Figure 1(c)), an electrolyte (numeral 4 in Figure 1(c)) and an air electrode (numeral 5 in Figure 1(c)) sequentially formed on a surface of a substrate (numeral 1 in Figure 1(c)) having an internal fuel flow path (numeral 7 in Figure 1(c)) provided therein. At least the surface of the substrate in contact with the cells and interconnectors is electrically insulating. The method comprises the steps of providing respective fuel electrodes on the surface of the substrate, providing a respective first part of the respective interconnectors having a density not

less than 90% of the theoretical density of the interconnector material or that would have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes, providing the respective electrolytes on the respective fuel electrodes, providing the respective electrolytes on the respective fuel electrodes, co-sintering the respective interconnectors, the respective fuel electrodes and the respective electrolytes (clean copy of specification page 8, lines 10-21 and specification page 32, lines 21-25)), forming respective air electrodes on the respective electrolytes and electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts (clean copy of specification page 8, lines 21-23 and specification page 32, lines 8-34).

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Whether Claims 13, 19-27, 29-33 and 36-41 are unpatentable under 35 USC 103(a) over Sato in view of Tsukuda, Bates and Barker. The second ground of rejection for review on appeal is whether Claims 7, 8, 17 and 18 are unpatentable under 35 USC 103(a) over Sato in view of Tsukuda, Bates and Barker and further in view of Akiyama. The third ground for review on appeal is whether Claims 9-12, 14-16, 28, 34 and 35 are unpatentable under 35 USC 103(a) over Sato in view of Tsukuda, Bates, Barker and further in view of Xue.

ARGUMENT

The presently claimed invention, in its broadest embodiment, is directed to a method of manufacturing a solid oxide fuel cell module made up of a plurality of cells provided adjacent to one another and electrically connected in series by an interconnector provided therebetween. Each cell is made up of a fuel electrode, an electrolyte and an air

electrode sequentially formed on a surface of a substrate having an internal fuel flowpath provided therein. At least a surface of the substrate in contact with the cells and interconnectors is electrically insulating. The method comprises the steps of providing respective fuel electrodes and respective electrolytes on the surface of the substrate, co-sintering the respective fuel electrodes and respective electrolytes, providing a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that will have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes, forming respective air electrodes on the respective electrolytes and electrically connecting the respective electrodes with the respective first parts of the respective interconnectors via respective second parts of the interconnectors which have a density less than respective first parts.

The present invention is based on the discovery that through using a dense material in the first part of an interconnector which comes into contact with a fuel electrode and electrolyte of a fuel cell, the gas-sealing performance is enhanced by preventing gas from leaking between the interconnector and the respective electrolytes and a secure electrical contact is achieved. The present invention also requires that a second part of the interconnector have a density less than that of the first part to enable the advantageous effect that the fabrication of the interconnectors can be implemented concurrently with the formation of the air electrodes or at a temperature lower than the sintering temperature of the air electrodes.

These aspects of the present invention are clearly not shown by the prior art cited by the Examiner.

REJECTION OF CLAIMS 13, 19-27, 29-33 AND 36-41
UNDER 35 USC 103(a) OVER SATO
IN VIEW OF TSUKUDA, BATES AND BARKER

The Sato et al reference is directed to a solid oxide fuel cell comprising a hollow dense substrate having a plurality of mounting holes formed on the surface thereof, cell sections provided in the mounting holes and interconnections provided between adjacent cell sections. The interconnections in this reference are disclosed as being a material having an electrical conductivity and that is stable in both oxidizing and reducing atmospheres. There is no discussion in this reference regarding the density of the interconnectors let alone requiring that one portion of the interconnector have a density different from another portion. The instant invention also requires that co-sintering be performed with at least two of the insulator substrates, fuel electrodes, electrolytes, interconnectors and air electrodes. In contrast thereto, Sato et al requires that a finished fuel cell be placed in cell attachment holes provided in a dense substrate and then the interconnectors are formed. Given these differences between Sato et al and the presently claimed invention, the secondary references cited by the Examiner must provide the motivation to one of ordinary skill in the art to modify Sato et al in a manner that would yield the presently claimed invention. The secondary references contain no such disclosures.

The Tsukuda et al reference is directed to a fuel cell comprising a fuel electrode and an air electrode disposed on side surfaces of an electrolytic film. Interconnectors 15 are provided on the fuel cell and the fuel electrode 12, electrolyte 13 and interconnector 15 can be co-sintered. There is no disclosure in this reference regarding a first portion of the interconnector having a different density than a second portion of the interconnector or suggest that any advantage would be gained by making such a distinction. As

such, Sato et al in combination with Tsukuda et al does not disclose the presently claimed invention.

The Bates reference has been cited by the Examiner as teaching that magnesium-doped or strontium-doped lanthanum chromites can be used as interconnectors and the Barker reference has been cited as teaching the use of a silver mixture, a silver alloy, or a silver composite for connecting different layers in solid oxide fuel cells. However, neither of these references teach the use of an interconnector having a first part with a density that is greater than a second part.

To explain away this obvious deficiency in the references cited by the Examiner, the Examiner states that making different parts of the interconnectors have different densities would be an obvious modification of the prior art. However, the Examiner has not made any credible explanation as to why this would be an obvious modification. Applicants have explained that by providing a dense material in a first part of an interconnector which comes into contact with a fuel electrode and electrolyte of a fuel cell, the gas-sealing performance is enhanced by preventing gas from leaking between the interconnector and the respective electrolytes and a secure electrical contact is obtained. By providing a second part of the interconnector with a density less than that of the first part, an advantageous effect of the fabrication of the interconnectors being implemented concurrently with the formation of the air electrodes or at a temperature lower than the sintering temperature of the air electrodes is enabled. The Examiner has not explained why these benefits would be obvious and, as such, it is respectfully submitted that Claims 13, 19-27, 29-33 and 36-41 are clearly patentably distinguishable over Sato in combination with Tsukuda, Bates and Barker.

REJECTION OF CLAIMS 7, 8, 17 AND 18
UNDER 35 USC 103(a) OVER SATO
IN VIEW OF TSUKUDA, BATES AND BARKER
AND FURTHER IN VIEW OF AKIYAMA

The Sato, Tsukuda, Bates and Barker references have been discussed above. The Akiyama reference has been cited as teaching that 20-50 wt.% of an oxide of magnesium can be used for the solid fuel cell tube substrate. However, Akiyama does not cure the deficiencies discussed above for Sato, Tsukuda, Bates and Barker with respect to providing the interconnectors having a first part in contact with the respective fuel electrodes and the respective electrolytes with a greater density than a second part which electrically connects the respective electrodes with the respective first parts of the respective interconnectors. As such, Sato in view of Tsukuda, Bates and Barker and further in view of Akiyama do not even present a showing of *prima facie* obviousness under 35 USC 103(a) with respect to Claims 7, 8, 17 and 18.

REJECTION OF CLAIMS 9-12, 14-16, 28, 34 AND 35
UNDER 35 USC 103(a) AS BEING UNPATENTABLE OVER SATO
IN VIEW OF TSUKUDA, BATES, BARKER
AND FURTHER IN VIEW OF XUE

The Sato, Tsukuda, Bates and Barker references have been discussed above. The Xue reference has been cited as teaching that stabilized zirconia and alumina can be used as a manifold support material but their relatively low thermal expansion coefficient will cause problems for thermal expansion mismatch and sealing the manifold to the stack. This reference has been cited as further teaching that yttrium, zirconium, nickel and scandium oxide can be used as additives for adjusting the thermal expansion for the manifold support material so it would have been obvious to use yttria-stabilized zirconia as shown by Xue to improve the solid oxide fuel cell manufacturing process of Sato in view of Tsukuda, Bates and Barker. However, Xue, like all of the previously cited

references by the Examiner, has no disclosure with respect to requiring a first part of the interconnectors, in contact with the respective fuel electrodes and the respective electrolytes, have a greater density than a second part of the interconnector which electrically connect the electrodes with the first part of the interconnector. Appellants have explained the advantages associated with such a construction and these advantages cannot be merely explained away by the Examiner stating that it would have been obvious to vary the density in different parts of the interconnectors, especially when the prior art has no such suggestion. As such, it is respectfully submitted that Sato in view of Tsukuda, Bates, Barker and further in view of Xue does not even make a showing of prima facie obviousness under 35 USC 103(a) with respect to Claims 9-12, 14-16, 28, 34 and 35 of the present invention.

CONCLUSION

For the reasons advanced above, it is respectfully submitted that the currently claimed invention clearly is patentably distinguishable over the prior art cited by the Examiner. Reversal of the Examiner is respectfully solicited.

Respectfully submitted,



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Encl: Claims Appendix
Evidence Appendix
Related Proceedings Appendix
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CLAIMS APPENDIX

7. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a mixture of MgO, and MgAl₂O₄ is used as a constituent material of the substrate and the interconnectors.

8. A method of manufacturing a solid oxide fuel cell module according to claim 7, wherein the mixture of MgO, and MgAl₂O₄ is a mixture of MgO, and MgAl₂O₄, containing 20 to 70 vol. % of MgO.

9. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein an yttria-stabilized zirconia expressed by chemical formula (Y₂O₃)_x(ZrO₂)_{1-x}, wherein x = 0.03 to 0.12, is used as a constituent material of the substrate and the interconnectors.

10. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a mixture of a mixture composed of MgO, and MgAl₂O₄, and an yttria-stabilized zirconia expressed by chemical formula (Y₂O₃)_x(ZrO₂)_{1-x}, wherein x = 0.03 to 0.12, is used as a constituent material of the substrate and the interconnectors.

11. A method of manufacturing a solid oxide fuel cell module according to claim 10, wherein the mixture of MgO, and MgAl₂O₄ is a mixture of MgO, and MgAl₂O₄, containing 20 to 70 vol. % of MgO.

12. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a constituent material of the substrate and the interconnectors is a material composed of Ni diffused in a range not more than 35 vol. %.

13. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a material composed mainly of Ni is used as a constituent material of the fuel electrode.

14. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a mixture of Ni and an yttria-stabilized zirconia expressed by chemical formula $(Y_2O_3)_x(ZrO_2)_{1-x}$, wherein $x = 0.03$ to 0.12 , with not less than 40 vol. % of Ni diffused in the mixture, is used as a constituent material of the fuel electrode.

15. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein an yttria-stabilized zirconia expressed by chemical formula $(Y_2O_3)_x(ZrO_2)_{1-x}$, wherein $x = 0.05$ to 0.15 , is used as a constituent material of the electrolyte.

16. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a scandia-stabilized zirconia expressed by chemical formula $(Sc_2O_3)_x(ZrO_2)_{1-x}$, wherein $x = 0.05$ to 0.15 , is used as a constituent material of the electrolyte.

17. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein an yttria-doped ceria expressed by chemical formula $(Y_2O_3)_x(CeO_2)_{1-x}$, wherein $x = 0.02$ to 0.4 , is used as a constituent material of the electrolyte.

18. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a gadolinia-doped ceria expressed by chemical formula $(Gd_2O_3)_x(CeO_2)_{1-x}$, wherein $x = 0.02$ to 0.4 , is used as a constituent material of the electrolyte.

19. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein a material composed of a

mixture of a glass and an electroconductive material is used as a constituent material of the interconnector.

20. A method of manufacturing a solid oxide fuel cell module according to claim 19, wherein the glass in the mixture of the glass and the electroconductive material is a glass with thermal expansion coefficient falling in a range of 8.0 to $14.0 \times 10^{-6} K^{-1}$.

21. A method of manufacturing a solid oxide fuel cell module according to claim 19, wherein the glass in the mixture of the glass and the electroconductive material is a glass with a softening point falling in a range of 600 to 1000°C.

22. A method of manufacturing a solid oxide fuel cell module according to claim 19, wherein the electroconductive material in the mixture of the glass and the electroconductive material is a metal.

23. A method of manufacturing a solid oxide fuel cell module according to claim 22, wherein the metal is at least one kind of metal selected from the group consisting of Pt, Ag, Au, Ni, Co, W, and Pd.

24. A method of manufacturing a solid oxide fuel cell module according to claim 22, wherein the metal is an alloy containing Ag.

25. A method of manufacturing a solid oxide fuel cell module according to claim 19, wherein the electroconductive material in the mixture of the glass and the electroconductive material is an electroconductive oxide.

26. A method of manufacturing a solid oxide fuel cell module according to claim 25, wherein the electroconductive oxide is a perovskite-type ceramics composed of not less than

two elements selected from the group consisting of La, Cr, Y, Ce, Ca, Sr, Mg, Ba, Ni, Fe, Co, Mn, Ti, Nd, Pb, Bi, and Cu.

27. A method of manufacturing a solid oxide fuel cell module according to claim 25, wherein the electroconductive oxide is an oxide expressed by chemical formula $(Ln, M)CrO_3$, wherein Ln refers to lanthanoids and M refers to Ba, Ca, Mg, or Sr).

28. A method of manufacturing a solid oxide fuel cell module according to claim 25, wherein the electroconductive oxide is an oxide expressed by chemical formula $M(Ti_{1-x} Nb_x)O_3$, wherein M refers to at least one element selected from the group consisting of Ba, Ca, Li, Pb, Bi, Cu, Sr, La, Mg, and Ce, $x = 0$ to 0.4).

29. A method of manufacturing a solid oxide fuel cell module according to claim 19, wherein the electroconductive material content of the mixture of the glass and the electroconductive material is not less than 30 vol. % of the mixture.

30. A method of manufacturing a solid oxide fuel cell module according to claim 19, wherein the mixture of the glass and the electroconductive material is subjected to heat treatment at not higher than the melting point of the electroconductive material after the mixture is applied between the fuel electrode of one of the adjacent cells, and the air electrode of the other cell.

31. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein only portions of the interconnector connecting the fuel electrode of one of the adjacent cells with the air electrode of the other cell, in contact with the fuel electrode, and the electrolyte, respectively, are formed of a material composed mainly of Ag.

32. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein only portions of the interconnector connecting the fuel electrode of one of the adjacent cells with the air electrode of the other cell, in contact with the fuel electrode, and the electrolyte, respectively, are formed of a material composed of one kind or not less than two kinds of material selected from the group consisting of Ag, Ag solder, and a mixture of Ag and the glass.

33. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein only portions of the interconnector connecting the fuel electrode of one of the adjacent cells with the air electrode of the other cell, in contact with the fuel electrode, and the electrolyte, respectively, are formed of an electroconductive oxide.

34. A method of manufacturing a solid oxide fuel cell module according to claim 36, wherein an oxide material containing Ti is used as a constituent material of the interconnector connecting the fuel electrode of one of the adjacent cells with the air electrode of the other cell.

35. A method of manufacturing a solid oxide fuel cell module according to claim 34, wherein the oxide material containing Ti is a material expressed by chemical formula $M(Ti_{1-x} Nb_x)O_3$, wherein M refers to at least one element selected from the group consisting of Ba, Ca, Pb, Bi, Cu, Sr, La, Li, and Ce, $x = 0$ to 0.4.

36. A method of manufacturing a solid oxide fuel cell module made up of a plurality of cells provided adjacent to one another and electrically connected in series by an interconnector provided therebetween, each cell comprising a fuel electrode, an electrolyte and an air electrode

sequentially formed on a surface of a substrate having an internal fuel flow path provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating, said method comprising the steps of:

providing respective fuel electrodes and respective electrolytes on the surface of the substrate;

co-sintering the respective fuel electrodes and respective electrolytes;

providing a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that will have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes;

forming respective air electrodes on the respective electrolytes; and

electrically connecting the respective electrodes with the respective first parts of the respective interconnectors via respective second parts of the interconnectors which have a density less than the respective first parts.

37. A method of manufacturing a solid oxide fuel cell module made up of a plurality of cells provided adjacent to one another and electrically connected in series by an interconnector provided therebetween, each cell comprising a fuel electrode, an electrolyte and an air electrode sequentially formed on a surface of a substrate having an internal fuel flow path provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating, said method comprising the steps of:

providing respective fuel electrodes and respective electrolytes on the surface of the substrate;

co-sintering the substrate, the respective fuel electrodes and the respective electrolytes;

providing a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that will have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes;

forming respective air electrodes on the respective electrolytes; and

electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts.

38. A method of manufacturing a solid oxide fuel cell module made up of a plurality of cells provided adjacent to one another and electrically connected in series by an interconnector provided therebetween, each cell comprising a fuel electrode, an electrolyte and an air electrode sequentially formed on a surface of a substrate having an internal fuel flow path provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating, said method comprising the steps of:

providing respective fuel electrodes, respective electrolytes and respective interconnectors on the surface of the substrate, a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that will have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes;

co-sintering the respective fuel electrodes, respective electrolytes and respective interconnectors;

forming respective air electrodes on the respective electrolytes; and

electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts.

39. A method of manufacturing a solid oxide fuel cell module made up of a plurality of cells provided adjacent to one another and electrically connected in series by an interconnector provided therebetween, each cell comprising a fuel electrode, an electrolyte and an air electrode sequentially formed on a surface of a substrate having an internal fuel flowpath provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating, said method comprising the steps of:

providing respective fuel electrodes, respective electrolytes and respective interconnectors on the surface of the substrate, a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that will have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes and the respective electrolytes;

co-sintering the substrate, the respective fuel electrodes, respective electrolytes and respective interconnectors;

forming respective air electrodes on the respective electrolytes; and

electrically connecting the respective air electrodes with the respective first parts of the respective

interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts.

40. A method of manufacturing a solid oxide fuel cell module made up of a plurality of cells provided adjacent to one another and electrically connected in series by an interconnector provided therebetween, each cell comprising a fuel electrode, an electrolyte and an air electrode sequentially formed on a surface of a substrate having an internal fuel flow path provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating, said method comprising the steps of:

providing respective fuel electrodes on the surface of the substrate;

providing a respective first part of the respective interconnectors having a density that is not less than 90% of the theoretical density of the interconnector material or that will have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes;

providing the respective electrolytes on the respective fuel electrodes;

co-sintering the respective interconnectors, the respective fuel electrodes and the respective electrolytes;

forming respective air electrodes on the respective electrolytes; and

electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts.

41. A method of manufacturing a solid oxide fuel cell module made up of a plurality of cells provided adjacent to

one another and electrically connected in series by an interconnector provided therebetween, each cell comprising a fuel electrode, an electrolyte and an air electrode sequentially formed on a surface of a substrate having an internal fuel flow path provided therein, at least the surface of the substrate in contact with the cells and interconnectors being electrically insulating, said method comprising the steps of:

providing respective fuel electrodes on the surface of the substrate;

providing a respective first part of the respective interconnections having a density that is not less than 90% of the theoretical density of the interconnector material or that will have a density of not less than 90% of the theoretical density of the interconnector material after sintering in contact with the respective fuel electrodes;

providing the respective electrolytes on the respective fuel electrodes;

co-sintering the respective interconnectors, the respective fuel electrodes and the respective electrolytes;

forming respective air electrodes on the respective electrolytes; and

electrically connecting the respective air electrodes with the respective first parts of the respective interconnectors via respective second parts of the respective interconnectors which have a density less than the respective first parts.

EVIDENCE APPENDIX

There is no extrinsic evidence relied upon by Appellants
in the appeal.

RELATED PROCEEDINGS APPENDIX

There are no related proceedings with respect to the present application.